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Vol. 43 No. 5

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MAY, 1916

The origin of new varieties of Nephrolepis by orthogenetic saltation

I. Progressive variations

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(WITH PLATES 10–15)

A. Introduction

1. *Definition and scope of paper*

The title, "The origin of new varieties in *Nephrolepis* by orthogenetic saltation," was selected to emphasize two points: first, that the variations to be described are discontinuous and of considerable magnitude, *i.e.* jumps or saltations; second, that these variations occur in definite series along a few limited lines, *i.e.* they are orthogenetic. I purposely beg the question as to whether they are mutations or not because I do not know. The exact application of the term, mutation, seems at present to be in a state of some uncertainty, and in any event, there may be considerable question about classifying these vegetative fern sports in the same category with the forms of *Oenothera*, among which, surely, orthodox mutations must exist.

Nephrolepis is a genus of tropical ferns, several species of which have been cultivated. Nearly all these species have shown some variation under cultivation, but one of them, *N. exaltata*, through its variety, the so-called "Boston fern," *N. exaltata bostoniensis*, has been especially prolific of new forms. From this variety there have arisen in about fifteen years at least sixty

[The BULLETIN for April (43: 169–206. *pl. 7–9*) was issued May 20, 1916.]

named horticultural forms besides a probably equally large number which have never gained horticultural recognition. The present account is concerned only with a portion of these Boston fern varieties, the basis of selection being indicated below.

Reproduction in the Boston fern and its varieties, as indeed in the varieties of the other species of *Nephrolepis*, is almost exclusively vegetative. The varieties with a few possible exceptions have arisen strictly by bud variation, the explanation being found in the fact that almost all the forms, the wild species being excepted, produce imperfect sori with mostly abortive sporangia. As indicated, there are a few varieties reputed to have been raised from spores and there is nothing impossible in this connection, but there is also no question that the great majority of forms have developed from bud sports. Their study is therefore untroubled by questions of pure line or hybridization, nor does it readily allow these valuable analytical methods of attack, but calls mainly for an accurate determination of the origin and parentage of each form and an adequate description of its characters.

The large number of varieties mentioned includes a multiplicity of forms, some of which have arisen by progressive, some by regressive, variation. A complete description of all these at present would involve considerable difficulties in the way of preparation and presentation. The scope of this paper is therefore limited to deal mainly with the more pronounced lines of progressive variation. The terms "progressive," "regressive," and "reversion," are used here with only their ordinary nontechnical connotation. Progressive variations as understood are those which show less resemblance to var. *bostoniensis* than do their parent forms. It must be understood here that the variations from var. *bostoniensis* include series of forms with as many as six successive intensifications of a given character by which the first of the series diverged from var. *bostoniensis*. Such a series is considered progressive (see PLATE 10). Regressive variations or reversions, on the other hand, are understood to be those which show something of a return in characters toward var. *bostoniensis*. This classification is largely one of convenience, and the separation of the two types of forms may not always be justified as made. It will, however, furnish a good basis for a description and discussion of these forms.

As preliminary to such description, it will be appropriate to consider some of the significant features of these variations, and to compare them with other variations of possibly similar nature. This discussion will be dealt with under two headings: viz., Earlier studies of orthogenesis; Conditions under which *Nephrolepis* varieties have originated.

2. *Earlier studies of orthogenesis*

The term "orthogenesis" was proposed by Haacke to characterize what the zoölogist, Eimer, had been calling "bestimmt gerichtete Entwicklung," *i.e.* "definitely directed evolution" as translated by T. J. McCormack.* It appears that the botanist, Nägeli, had expressed views similar to those of Eimer at a somewhat earlier date. The evidence upon which these writers built their conclusions was systematic, and dealt with groups of living species showing close relationship. An orthogenetic series for Eimer was, for example, a group of related butterflies, the relationships between which was traced by gradations in the markings which varied from one extreme to another, but were connected by intervening forms. Evolution was postulated as progressive in one direction or the other.

Later writers, such as Cope, Hyatt, Grabau, and Osborn, have considered orthogenesis in connection with groups of organisms in geologic series. Grabau, for example, has illustrated orthogenesis in gastropods† by series of fossils from successive strata, which show gradual but definite progressive variation in the sculpture of the shells.

A third line of orthogenetic study is illustrated by Coulter's recent discussion of orthogenesis in gymnosperms.‡ This, of course, is similar to that of Grabau, Hyatt, etc., in that it deals with extinct forms, but differs in being applied to a much longer period of variation and to less closely related forms, and it differs further in that it deals with the evolution of *organs* as such, the egg, proembryo, seed, etc., rather than with the phylogeny of *organisms.*

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* Eimer. On orthogenesis. Chicago. 1898.

† Studies in Gastropoda III. Am. Nat. **41**: 607–651. 1907.

‡ Science II. **42**: 859–863. 1915.

The conclusions reached by the writers specified above are like those of any similar morphologic or systematic research, but differ in the use of the term "orthogenesis," instead of "tendency to vary," "trends of variation," or some similar expression. This difference is of interest, however, because it lays emphasis on the belief that the evolution of the present-day organic world has not been by chance fluctuation, but has proceeded in an orderly fashion in a law-conforming way. According to orthogenetic theory, evolution proceeds, at least in part, by the progressive intensification of characters in any series of forms, regardless of considerations of adaptation or utility. In the long run, of course, only such forms as possess useful characters will survive.

In the present case, the lines of variation do not appear to be in the interests of utility. The new forms produced are not as adaptable to natural conditions as the original species from which they all originated. Proof of this is found in the fact that the various new varieties are, in general, more difficult of cultivation than the original form, and further proof is contained in the fact that none of the varieties of *N. exaltata bostoniensis* have been found wild in the tropics. It may appear then that these fern varieties, produced so artificially and unnaturally, are poor forms to cite as illustrations of orthogenesis. This would be true were it not for the fact that the same types of variation appear everywhere among ferns as distinctive of recognized species or even genera. That is, fern species *have* differentiated naturally by the same manner and degree of variation as is shown by these horticultural varieties. On this basis, these Boston fern sports may be considered as unsuccessful variations, either premature or normal, perhaps called forth or at least perpetuated by the unusual cultural conditions. Like wild forms in other genera in the degree of their variation, they are unlike them in having developed no means of maintaining themselves under natural conditions, and if put to the test of competition, would soon be disposed of by natural selection. They may be said to indicate potentialities of variation in *Nephrolepis*. It is worth while noting that variations of similar type *but of spore origin*, have appeared in other fern genera, notably *Polypodium* and *Polystichum*.

3. *Conditions under which Nephrolepis varieties have originated*

It is suggested in the preceding paragraph that cultural conditions may be responsible in some degree for the development or preservation of so many new varieties. Two points are of special interest in connection with the cultural conditions: first, the fact that these are probably generally the optimum for these ferns; second, the very large numbers of individual plants raised each year.

For soil, the florist uses a good loam or leaf mould with at least one half to equal amounts of rotted manure. In one case the mixture used consists of one part sand to five parts rotted manure, leaf mould, and humus. New plants are propagated from stock plants which are planted out in long benches in shallow soil. A single stock plant may produce nearly one hundred runners, as the young plants are called, in a single year. These new plants develop from slender stolons which spring from the parent plant close to or connected with the leaf bases, and penetrate the soil in all directions. Each runner may produce a considerable number of buds as well as roots. It is worthy of present note that these stolons serve not only for reproduction but also as agents in the nourishment of the parent plant, at least until the secondary plants have attained some size. The main point to be noted in connection with the methods of propagation aside from the quality of the soil, etc., is the freedom of growth which is given the stock plants and their progeny in the early stages. The plants after potting are sometimes further fed with liquid fertilizer of some sort. They are grown in low-roofed houses with absence of draft, and usually with no other kinds of plants which might desire slightly different conditions. If variation is in any way connected with vigorous growth, there is every reason why these ferns should vary.

With respect to the number of plants grown per annum, it is hard to estimate in what will appear a conservative manner. I have talked with two growers who claimed to sell three and four hundred thousand small plants every year and there seemed to be no reason why they should be exaggerating. There are undoubtedly half a dozen florists in the eastern states who raise over one hundred thousand plants each year, and a larger number who produce fifty thousand. The number who grow fifteen to twenty thousand is of course much larger still. Some deduction from the total thus indicated must be made in connection with smaller growers because of the fact that many buy part or all of their stock of ferns each year as small plants to raise to larger sizes. A single plant may thus be sold twice at wholesale, and once at retail, and the non-growing jobber may come in to make a third wholesale transfer. Taking everything into consideration, however, it seems safe to put the total number of plants raised every twelve months at not less than one million, and probably nearer two. As will readily be seen, this immense number offers large possibilities for the occurrence of variation.

A third factor connected with the selection and preservation of new varieties of these ferns is found in the fact that some of these varieties have been the means of large profits to their producers. The first good two-pinnate sport of var. *bostoniensis* created a furor in the florist trade, and was awarded gold medals and other insignia which no other new plant has ever received. The regular price for a small plant of a standard variety from a two and a half inch pot is five cents in hundred lots. New forms of merit now sell at introduction for twenty-five cents apiece, and some new forms have sold as high as one dollar per plant. In the past this has led to the exercise of great watchfulness for new forms of possible merit, and has thus aided in the discovery and development of new varieties. So many forms have now been developed, however, that there appears to be a reaction from the interest in new forms.

The figure as to the number of plants grown per year suggests the possibility of determining an approximate coefficient of variation, but this seems to be an almost impossible problem. For one variety about which I have made inquiry, the number indicated is at least one in three thousand. For another variety which is appearing rather frequently in different establishments at present, the coefficient is undoubtedly higher, perhaps one in one thousand. For yet another variety a figure of one in a million is probably too high an estimate. It should be added that these figures are for progressive variations only. Reversions or regressive variations appear much more frequently as a rule.

Two conclusions are evident from the foregoing: (1) the coefficient of variation differs with different varieties; (2) the coefficient of variation is never high for progressive variations.

4. *Methods of study*

One method of study of the Boston fern problem is indicated by the above facts as almost obligatory, viz., frequent visits to florists' establishments for purposes of observation. During the last two years I have visited nearly all the leading fern growers in the eastern states. Visits have been made to the greenhouses of the growers in Massachusetts, New York, New Jersey, Pennsylvania, and Ohio, who have produced practically all the new forms of *Nephrolepis* raised east of the Mississippi. These visits are being continued, and arrangements have been made for experimental work through the coöperation of some of the growers.

A second method of study has been connected with the assembling of a living collection of all obtainable varieties of these ferns at the Brooklyn Botanic Garden. These collections now number at least seventy-five varieties, nearly all obtained directly from their original producers, and orders are now in the hands of English and French growers for foreign varieties which will raise the total number to over one hundred. Requests have also been sent to a number of stations in the tropics for the collection of wild forms with a view to obtain a good representation of both horticultural and natural forms.

Still a third method which is really a combination of the other two has consisted in the introduction to florists all over the country of varieties with which they were not familiar. A large number of small plants have been sent out in this way. The benefit to the investigation will come in connection with future visits when a much larger number of varieties will be available for observation. A considerable number of new forms have also been obtained in this way by exchange.

It will be noted that there is little opportunity for the experimental production of new progressive variations in connection with the Botanic Garden collection. Not enough plants can be grown. In the florists' establishments, the number of plants may be large enough but it is not always possible to control all conditions or to find sufficient time for regular and thorough observation.

The greatest difficulty which inheres in the study of the known forms of these ferns is connected with the possible inaccuracy of the growers. For the facts as to the origin and parentage of each variety it is necessary to rely almost wholly on the statement of the florist who produced it. With every desire for accuracy, the grower may easily be mistaken with respect to the relationship of any given form, even if it has been under his eye since its first appearance. Plants of various forms are often grown together in stock beds, and the stolons may spread two or three feet in all directions with consequent mixing of the runners. When a form is discovered by one florist and sold for development and introduction to another, there is still greater chance for inaccuracy.

In general, however, there is every reason for believing that the statements which follow regarding the origin and relationship of the varieties are in the main accurate. Many of them, nearly all, in fact, are established beyond the possibility of any reasonable doubt. A few are definitely indicated as open to possible question.

It is a pleasure to acknowledge indebtedness to the numerous florists who have contributed to the living collections which have been built up almost exclusively by their gifts of plants. A nearly complete list of the contributing florists is given at the end of this paper in connection with an index of the varieties. To Mr. W. R. Maxon, of the United States National Museum, my thanks are due for valuable information regarding his collections and observations of these ferns in the tropics. For the opportunities at the Brooklyn Botanic Garden, without which complete data could not have been accumulated, I am glad to make grateful acknowledgment to Dr. C. Stuart Gager, the director. To Dr. O. E. White of the same institution I am indebted for a reading of my manuscript and a number of suggestions. Finally the study has been aided by a grant of one hundred dollars from the American Association for the Advancement of Science, made at the Columbus meeting, which will be applied to the expenses incident to the visits to florists. Only a small part of this has so far been used, most of the visits to date having been made at private expense.

B. ORIGIN AND DESCRIPTION OF THE VARIETIES IN NEPHROLEPIS

1. *N. exaltata and N. exaltata bostoniensis*

Nephrolepis exaltata, or rather its variety *bostoniensis*, has been named as the form from which the variations under consideration have all originated. As already noted, a number of other species in the genus have also given rise under horticultural conditions to variations similar to those of *N. exaltata*, but none of the other species has received as extensive cultivation, and there has, therefore, been less opportunity for variation. It may be noted here that all the wild species forms of *Nephrolepis* are once-pinnate. This is significant in consideration of the fact that among the varieties of *N. exaltata bostoniensis* are two-, three-, four-, and even five-pinnate forms. So far as I have been able to discover, only two partial aberrations from the once-pinnate type have been found wild; one, *N. biserrata* ("*davallioides*") *furcans*, with dichotomously divided pinnae, the so-called "fish-tail" form of the florists (see PLATE 12, FIG. 3, for illustration of this type of variation in the variety *falcata*); and the other, the anomalous form known as *N. Duffii* from New Zealand, referred by Goebel to *N. cordifolia* as a variety.

N. exaltata is a species of common and general occurrence in tropical America, and of somewhat scattered distribution in the Old World tropics. As I have it from Porto Rico, it appears as a plant with narrow erect leaves with sharply acute pinnae (PLATE 13, FIG. 1), well deserving its common name of "sword fern."* The sori are well developed and large with many fully formed sporangia. Presumably this form has been in cultivation in America for over fifty years, although the source and exact character of the original introduction are uncertain. It seems to have been first introduced into cultivation in 1793, at Kew, and came from Jamaica. The date of its American introduction I have not yet been able to discover, although this is a matter of considerable interest, especially with respect to the origin of the variety *bostoniensis*. Between 1890 and 1895 florists discovered that there were in cultivation under the name of sword fern two distinct forms, the one as above described, the other (see PLATE 13, FIG. 2) laxer, with broader leaves, upon which the sori and sporangia were small and abortive. The second form was also more rapid in growth.

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* There is a great deal of confusion in the trade use of the names "sword fern," "Boston fern," and *Nephrolepis exaltata*. In Florida, Dr. J. K. Small tells me the wild species, *N. exaltata*, is called "Boston fern," and the term "sword fern" is applied to the other Florida species, *N. biserrata*, a very different thing. Several florists, at least, list as *N. exaltata*, the dissimilar *N. cordifolia*, a further element of confusion.

There are two versions of the origin and discovery of this second form which afterward came to be known as the "Boston fern," or "Boston sword fern." According to one version, the variety was first discovered among a lot of two hundred small plants shipped as plain sword fern by the Robert Craig Company, of Philadelphia, to F. C. Becker, of Cambridge, Massachusetts. It is certain that the latter florist was among the first to recognize the importance of the second form which he at first identified as *N. davallioides*. Under this name a considerable number of plants were sold. This identification was later challenged by G. W. Oliver, of Washington, who finally convinced Becker after a considerable exchange of opinion in the Florists' Exchange* that the fern in question was at least not *N. davallioides*, or, as it should be called, *N. biserrata*. The dispute ended according to the citations referred to by September 12, 1896. Becker stated that the plant had been submitted to a fern expert by the Nomenclature Commission of the Society of American Florists, and his advertisement was changed so that the fern was listed henceforth as *N. exaltata bostoniensis*.

The other version has recently received a convincing statement in the Florists' Exchange† by F. W. Fletcher, of Auburndale, Massachusetts. According to this version, the Boston fern, when attention was first directed to it, was in the hands of several growers, particularly about Boston. Many of these growers were of the opinion that they were the discoverers of it, but there seemed to be no way of determining its real origin. At any rate it was referred to the Nomenclature Commission of the Society of American Florists as stated above, and by them submitted first to Kew, and later to G. W. Davenport. The latter is said to have been responsible for its identification as a variety of *N. exaltata*, and the assignment of the varietal name *bostoniensis*, because of its prevalence in the neighborhood of Boston. Supporting this statement, there is a single, small, and immature, leaf of var. *bostoniensis* preserved in the Gray Herbarium with Davenport named as collector and dated in 1896.

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* **8**: 23; 57; 92; 122; 814; 858. 1896.

† **40**: 1134, 1135. 20 N 1915.

It may be noted that the second account does not preclude the possibility that a single florist, perhaps Becker, may have been originally responsible for the discovery of the new form. It is generally admitted that he had much to do with its exploitation and dissemination. It should be added, however, that some florists are of the opinion that the form has been in existence as long as forty years. A factor of great present uncertainty lies in the possibility of errors in identification on the part of florists. At present a number of florists are offering as *N. exaltata* a very different form, the species, *N. cordifolia* or *N. tuberosa*. Absolute nomenclatorial accuracy seems still to be beyond the abilities of botanists, even systematists, so that florists may be forgiven for occasional lapses, but the occurrence of such lapses indicates that the origin of var. *bostoniensis* may necessarily remain in the category of unsolved mysteries.

The study of tropical collections of *Nephrolepis*, both living and herbarium, may throw some light on this mystery. Another source of possible enlightenment lies in a study of the sources from which this species was introduced into cultivation. The possibilities of variation in a species so widely distributed as *N. exaltata* are too great to be overlooked. It is not impossible that the variety *bostoniensis* may have had a direct importation from the tropics.

2. *Sports from var. bostoniensis*

No matter what may be the uncertainty regarding the ancestry of var. *bostoniensis*, there is little or no uncertainty regarding its progeny. In the course of less than twenty years, it has given rise, directly and indirectly, to at least one hundred different forms. Its known first generation descendants probably number no more than twelve. The remaining ninety odd represent third, fourth, fifth, or even later generation sports of vegetative origin.

The forms which are claimed as direct sports from var. *bostoniensis* are as follows: *Piersoni* (PLATE 10, FIG. 2; PLATE 11, FIG. 2), *Schilleri, Anna Foster, Amerpohli* (PLATE 11, FIG. 7), *Harrisi* (PLATE 13, FIG. 3), *Roosevelti* (PLATE 13, FIG. 3), *Scotti* (PLATE 14, FIG. 2, 5), *Schultheisi, Giatrasi* (PLATE 15, FIG. 2) and *Wittboldi.* These forms do not represent ten diverse lines of variation, but three, or at most four or five. *Piersoni, Schilleri, Anna Foster,* and *Amerpohli* show an increase in leaf division from the once-pinnate type of var. *bostoniensis. Schilleri* seems to be an approximation of the form shown by *Piersoni,* which appeared more than ten years earlier. Both are twice-pinnate, as is *Anna Foster,* but the latter shows further differences in the shape and size of the ultimate segments, and other features. *Amerpohli* is thrice-pinnate, and, if directly descended from *bostoniensis,* represents a skipping of the twice-pinnate stage.

Scotti (PLATE 14, FIG. 2, 5), *Schultheisi,* and *Giatrasi* (PLATE 15, FIG. 2) are dwarf sports of var. *bostoniensis. Schultheisi* seems to be an approximate repetition of *Scotti,* ten years afterward. *Giatrasi* is well distinguished from the other two dwarfs in characters of growth habits, leaf form, etc., so that there may be said to be at least two distinct kinds of dwarf sports.

Harrisi and *Roosevelti* (see PLATE 13, FIG. 3) are almost exactly alike in respect to the leaf characters, but both differ from var. *bostoniensis* in having the pinnae more wavy or undulate, due to an increase in the parenchymatous part of the pinnae especially along the margin. *Wittboldi,* for which a spore origin is claimed, was originally described as "twice as wide as var. *bostoniensis,* and with wavy pinnae." As yet I have no surely authentic plants, and so cannot speak with certainty. The original introducers do not have the plant in stock now, but the material at hand named *Wittboldi* indicates that var. *bostoniensis* was probably not the parent form. The new form may have arisen as a chance sporeling, the result of the accidental introduction of some entirely different form, a very frequent occurrence in greenhouses. Herbarium specimens from Florida indicate that there may also be a "fish-tail" sport of var. *bostoniensis,* not included in the list of sports named above. There have probably been a few other variations of var. *bostoniensis,* either like those already named, or so unsatisfactory from the florists' point of view that they have not been preserved.

Eliminating the last two mentioned types, *Wittboldi* and the "fish-tail" form, there remain then three main lines of variation from var. *bostoniensis*, namely: a line showing increased division in the leaf, a line showing increased waviness or ruffling of the pinnae, and a line showing dwarfing. These types of variations are referred to as "lines of variation" because they represent the beginning of the orthogenetic series already mentioned, series in which these three kinds of variation are repeated in intensified

- EXALTATA-. . . . . .*bostoniensis*. .
  - **Piersoni** . . . . . .
    - **Barrowsi** . . . . **Whitmani**. . . . .
      - WHITMANI-"IMPROVED"
      - **Whitmani-compacta**
      - **Magnifica**
      - **Gracillima**
      - **Goodi**
      - Elmsfordi
    - PIERSONI-"IMPROVED"
    - **Elegantissima** . . ELEGANTISIMA-"IMPROVED"
    - **Elegantissima-compacta**. . . . . **Sport like Whitmani-compacta**
    - Superbissima . . . **Muscosa**
    - SPLENDIDA
  - **Schilleri**
  - **Anna Foster**
  - **Amerpohli**. . . . . . **?Smithi** . . . . **Craigi**
  - *Harrisi*. . . . . *Wm. K. Harris*
  - *Roosevelti* . . . . . .
    - *Sport like Wm. K. Harris*
    - Teddy Jr. . . . .
      - Dwarf sport. . FISH-TAIL SPORT
      - Randolphi
      - Smallest dwarf
  - Scotti . . . .
    - FALCATA
    - Wagneri
    - **Scholzeli** . . . . **three-pinnate sport**
  - Schultheisi
  - Giatrasi. . . . . . .
    - Dwarf sport
    - **two-pinnate sport**
  - WITTBOLDI

GENEALOGICAL CHART OF PROGRESSIVE SPORTS OF *bostoniensis*

Black face type indicates division sports.
Italics indicate sports showing ruffling.
Plain Roman type indicates dwarfing.
Small capitals indicate other kinds of variation.

form in one or more further vegetative generations. In these three lines occur all the illustrations of progressive orthogenetic variation about which this paper is mainly concerned. Reversion or regressive variation is also common, but need not be considered here.

The variations classified as progressive according to the distinction already made are all arranged according to their origin in the chart on page 219. It should be understood that no attempt has been made at this time to include the English forms, as they are not yet available for study, but enough is known to indicate that they do not represent any kind of variation not shown by American forms.

The direct sports from var. *bostoniensis* are of further interest in connection with the present discussion only as they have given rise to progressive variations. Upon this basis we may eliminate at once the varieties, *Schilleri*, *Anna Foster*, *Schultheisi*, and *Wittboldi*. It does not follow that these varieties have no potentialities of variation. Their failure to vary has probably been due only to the fact that they have never been extensively cultivated, and this in turn, has been due to the fact that they have not offered to the florist sufficient inducement in the way of horticultural possibilities. It remains then to consider the other *bostoniensis* sports according to the lines of progressive variation which they exhibit.

3. *Progressive division of the leaf*

(PLATES 10–12)

Of the original *bostoniensis* varieties showing an increase in leaf division, *Piersoni* is of most importance. From this form have come three or possibly four types of sports, viz., varieties showing further increase in division, *Barrowsi*, *elegantissima*, and *elegantissima-compacta*: varieties showing dwarfing, *superbissima;* a variety with forked pinnae, *splendida;* and a so-called "improved" form, *Piersoni* "improved."

Piersoni represents a twice-pinnate sport from the once-pinnate var. *bostoniensis*. *Barrowsi* shows a slight increase in the lobing of the pinnulae, that is, it is twice-pinnate pinnatifid. *Elegan-*

tissima (PLATE 12, FIG. 1) and *elegantissima-compacta* (PLATE 12, FIG. 2) are, however, more divided, in some leaves as much as thrice-pinnate. *Elegantissima-compacta* is of further interest because it is also a dwarf, thus combining two lines of variation at once.

Piersoni "improved" illustrates a type of variation which is of special interest to florists, and to which they seem generally to apply the name "improved," as, for example, *elegantissima* "improved" and *Whitmani* "improved." All the forms in the division series revert more or less, that is, throw once-pinnate leaves, and sometimes runners, *i.e.* plants which revert as a whole. The florist objects to these mixed plants and selects for greater stability. When he obtains stock showing less reversion, he is likely to call it "improved." There is great variation in the matter of reversion. Some kinds are relatively stable from their first appearance, others may produce as many reverting leaves as of the new type. Usually in order to keep stock true to type, a florist must exercise care in the selection of the runners which are used as stock plants.

Another illustration of dwarfing from *Piersoni* apparently of a brachyotic nature is represented by the variety *superbissima* (PLATE 12, FIG. 4), which is much less than half as long as its parent form. The dwarfing has been achieved mainly by a radical shortening of the rachis, with proportionately less decrease in the size of the pinnae. The resulting leaf is dense, stiff and twisted, of no particular grace, but interesting as an oddity. Like *Piersoni*, *superbissima* exhibits considerable reversion, and as yet no certain "improved" or non-reverting form has been obtained.

The sixth sport of *Piersoni* which may be classed as progressive, exhibits the kinds of variation prevalent though not common throughout the fern order, that is, the forking or dichotomy of the leaf apex or of the segments. In this form, called *splendida* (PLATE 12, FIG. 3), the pinnae show the forking, and a single plant may bear at one time several kinds of leaves, once-pinnate, twice-pinnate, and forking.

Referring again to the form *superbissima*, it may be noted here that from this there has come, as from *Piersoni* itself, a further sport showing progressive increase in the division of the leaf.

This variety is called *mucosa* (PLATE 12, FIG. 6) because of the dense, finely divided condition of the leaf. It seems to represent the same amount of division of leaf as is seen in the forms *elegantissima* and *elegantissima-compacta*, that is, it is thrice-pinnate. Tracing the ancestry of *muscosa*, we find the four forms, *bostoniensis*—*Piersoni*—*superbissima*—*muscosa*, which are, respectively, one-pinnate, two-pinnate, dwarf, and three-pinnate.

Two generalizations are suggested by the facts shown in the preceding series, and borne out by others to be shown later, which, if thoroughly understood, will simplify the description and explanation of the remaining forms. They rest not only on these few examples, but, as will appear, are true in the case of nearly all the variations considered in this paper.

1. Progressive variation takes place naturally along the three lines already described, viz., increase in leaf division, increase in ruffling or crisping, and dwarfing.

2. Any form which has not reached the limits of possibility in variation along the first and last mentioned lines, may be expected to give rise to new forms showing further progressive variation in one or both of them.

To particularize, we may say that any once-pinnate form may be expected to give rise to a twice-pinnate variety. A twice-pinnate variety may be expected to give rise to a thrice-pinnate form. The most highly divided form which has so far appeared is five times pinnate (see PLATE 10, FIG. 5; PLATE 11, FIG. 6), and there appear to be constitutional physiological reasons why further division is unlikely. As is the case in the progressive division in the leaf, so also with dwarfing or pumilism. Any large form whether once- or twice-pinnate, may be expected to give rise to a dwarf variety, as *superbissima* was derived from *Piersoni*, and as dwarf forms have occurred in the other series to be described below. With respect to progressive increase in ruffling, it is uncertain whether the second generalization applies to this line of variation or not. It may be that it does not apply in this line at all, or it may be that in the division series, a change in the degree of waviness would be too relative to admit of exact determination. It is certain that dwarfing occurs in all three lines, and that increase in division occurs also in the dwarfing series. Whether increase in division also occurs in the frilled or ruffled series is yet to be determined.

Of all the varieties of *Piersoni*, *Barrowsi* is perhaps of greatest interest because it has given rise to at least two further generations (vegetative) of division sports. From *Barrowsi* has come *Whitmani*, a clear increase in division, and from *Whitmani* have come several sports showing still more division.

Of the sports of *Whitmani* (PLATE 10, FIG. 3; PLATE 11, FIG. 3) named on the chart, *Whitmani* "improved" represents a more stable form, *i.e.* less given to reversion. *Whitmani-compacta* is a trifle smaller than its parent form, and has a fuller leaf with more expanded segments. *Goodi* and *Gracillima* (PLATE 11, FIG. 4; PLATE 12, FIG. 5) are apparently separate occurrences of the same variety, entirely thrice-pinnate, and with smaller segments than *Whitmani*. It may represent a dwarfing. *Magnifica* (PLATE 10, FIG. 4; PLATE 11, FIG. 5) is clearly four times pinnate, and represents the greatest amount of division which can be definitely stated to have been evolved in this particular series. *Elmsfordi* (PLATE 12, FIG. 7), a reputed spore sport, looks much like a miniature *Whitmani*, being less than half its size. It is different in another particular, in that it produces a much greater number of leaves to each crown, and in a given size pot. A plant grown to full size in a four-inch pot may show as many as a hundred leaves. In a twelve-inch pan, an estimate of a thousand leaves appeared conservative.

The other progressive sports in the *Piersoni* line are sufficiently described for the present by the typography of the chart and by the figures in plates 10–12.

The other reputed *bostoniensis* sport from which further progressive variations in the line of division are believed to have come is *Amerpohli*, a thrice-pinnate variety. *Amerpohli* in leaf division is very like *magnifica*, and in growth habit and carriage of the leaf it is also similar. Because of this close resemblance it is more than reasonable to suggest that it may really have come from *Whitmani* as a sport and that its reputed origin from var. *bostoniensis* may be an error. From *Amerpohli*, the four times pinnate form, *Smithi*, is said to have come. There is some question as to the correctness of this assertion but none regarding the fact that from

Smithi a five times pinnate form, *Craigi* (PLATE 10, FIG. 5; PLATE 11, FIG. 6), has come. This form is particularly interesting as exemplifying what is at present the highest amount of leaf division that has been attained by these forms. *Craigi* is illustrated in the plate with *Piersoni* not as necessarily derived from this but in order to complete the possible series of division forms. In that plate *Barrowsi* has been omitted because I have not yet been able to get a mature leaf of it.

As appears most noticeably on the plates illustrating these division forms, the increase in pinnation seems generally to be accompanied by a striking decrease in the size of the leaf, that is, in the total area. It is probable, however, that the actual leaf surface area remains the same, the apparent decrease being compensated for by the multiplication of the segments which may even expose more actual surface.

4. *Progressive increase in ruffling of the leaf*

(PLATE 13)

The series showing progressive increase in ruffling or crisping of the leaf begins with the original species, *N. exaltata* (PLATE 13, FIG. 1), because one of the characters in which var. *bostoniensis* (PLATE 13, FIG. 2) departs from the typical *N. exaltata* is in this feature. From var. *bostoniensis* there have been two more ruffled sports, *Harrisi* and *Roosevelti*, almost duplicating each other in appearance, but well distinguished as regards their progeny. PLATE 13, FIG. 3, may represent either *Harrisi* or *Roosevelti*, and PLATE 13, FIG. 4, may represent the variety *Wm. K. Harris*, or a coördinate form of similar appearance derived from *Roosevelti* but unnamed. Both are alike in leaf characters including crisping of pinnae, and both represent the highest development of this character which has been obtained in a direct progressive series. It will be noted that with the increase in crisping there has come also a tendency to develop auricles on the pinnae. This is of interest because it is a feature characteristic of wild varieties of other fern species.

The form described above represents the final sport so far obtained from the *Harrisi* line. From the *Roosevelti* line, however, two additional generations have appeared, showing progressive dwarfing. The first, called *Teddy Jr.* (PLATE 13, FIG. 5), has the characteristics appropriate to the principles of its namesake, as it appears to be the most prolific in producing new progressive variations of any *Nephrolepis* form. These new variations have appeared in three forms, but the interesting feature about them is that they are apparently common wherever *Teddy Jr.* is grown. In other words, *Teddy Jr.* shows a high frequency of variation.

Teddy Jr. is about half the size of the parent form *Roosevelti*. The three new forms are further dwarfs as shown in PLATE 13, FIGS. 6–8, respectively, the last being the smallest of the three and perhaps brachyotic. Only one, the middle-sized one, has been named as yet, being called *Randolphi* (FIG. 7) or "Baby Randolph." The smallest form may come directly from *Teddy Jr.* or it may also, according to report, arise as a sport from the largest of the three *Teddy Jr.* dwarfs.

It will be noted that the illustrations indicate that the amount of frilling continues to increase in the successively smaller forms. This increase, however, is probably to be correlated with the dwarfing, and should not be interpreted as in the line of progressive increase in ruffling.

From the largest of the three dwarf sports from *Teddy Jr.* there has just come to my attention a fish-tail sport, a form of variation apparently possible in all ferns.

5. *Progressive dwarfing*

(PLATES 14 AND 15)

Finally we have the series showing progressive dwarfing directly from var. *bostoniensis*. This seems to have occurred in three separate instances. The forms *Scotti* (PLATE 14, FIGS. 2, 5) and *Schultheisi* appear to be very similar, but independently derived. Of these *Scotti* is particularly interesting because it has given rise to other sports. *Giatrasi* (PLATE 15, FIG. 2) is also interesting for the same reason, and because it has distinctive features of its own. Neither of these dwarfs seems to be brachyotic.

Scotti (PLATE 14, FIGS. 2, 5) differs from var. *bostoniensis* not only in being smaller, but also in having blunter more wavy pinnae, and in having both leaves and pinnae more or less arched. From *Scotti* have come dwarf and division sports, as well as a fish-tail form. The further dwarf is called *Wagneri* (PLATE 14, FIGS. 3, 6), and seems to represent merely a foreshortening of the *Scotti* form with an intensification of the arching.

The division sport of *Scotti* is called *Scholzeli* (PLATE 14, FIG. 7), and is practically a miniature *Piersoni* in the type of division, shape of pinnae, et al. From *Scholzeli*, a two-pinnate form, has come a three-pinnate sport (PLATE 14, FIG. 8) to which no separate name has been given. It has been sold as *Scholzeli.* It corresponds to *Whitmani* in the division series proper, and like this would undoubtedly give rise to a four-pinnate form if grown in sufficient numbers.

Giatrasi (PLATE 15, FIG. 2) is little more than half as large as *Scotti*, and differs further in being slower growing, in producing a larger number of leaves per crown, and in the characteristics of individual leaves as well. These are thinner, have undulating rachides, and the pinnae are shorter and blunter. Because of its slower habits of growth, it appears to have found favor only with its introducer, George Giatras, in whose establishment some five to ten thousand plants are grown each year. Under these conditions it has given rise to two further sports, both as yet unnamed. One of these is a further dwarf (PLATE 15, FIG. 3), and the other is twice-pinnate (PLATE 15, FIG. 4). These new forms seem to partake of the slower growth habits of *Giatrasi*, and are therefore unlikely ever to be grown in quantity. This is unfortunate from a scientific point of view, as their further development and possible sports would be of considerable interest.

C. GENERAL CONSIDERATIONS

Some general considerations suggest themselves as a result of the foregoing descriptions; for example, the character and significance of the reversions, the possibilities of spore reproduction and segregation of forms, the possible results of morphological and cytological studies, etc. Nothing, however, is to be gained by speculation along these lines in the absence of additional facts. The reversions are under observation, and I hope that another growing season may allow the accumulation of sufficient information to make possible a description of these forms. Furthermore, the forms which have been so incompletely described in the preceding pages are worthy of a more careful and detailed study and description. I hope also to start spore cultures within a few weeks, using not only material known to be spore-fertile, but also forms presumably spore-sterile in the hope that apospory may result. There are indications that this phenomenon may occur.

Before concluding the present consideration, there are, however, two or three phases of the topic to which attention should be directed, by way of emphasis upon the significance of the variations which have been described.

First, further emphasis should be laid upon the separateness of the forms inter se. They are entirely discrete and distinct, and in this respect, are in accord with the characteristics ascribed to mutations. The individuals of a given variety show great uniformity under any given conditions of cultivations, and do not pass by imperceptible differences into related varieties. The fact that reversion takes place does not alter the separateness of the different varieties. In fact the reversions themselves furnish the best possible evidence of the distinctiveness and lack of continuity between even closely related varieties. The truth of this statement is established by the fact that the reversions are rarely if ever complete. A twice-pinnate variety may show some once-pinnate leaves and may give rise to new plants with once-pinnate leaves, but these once-pinnate leaves do not show a complete return to the form, size, etc., of the leaves of the original once-pinnate variety. The leaves of the reverted plant tend always to retain something of the character of the twice-pinnate plant. It appears then that the process by which the twice-pinnate form was produced from the original once-pinnate form must represent a protoplasmic change which is retained to some extent, even in the reversion. I cannot say that reversion may never be complete, but I have not yet found any cases where it is. This fact, however, that in any given progressive variation, a constitutional change is effected so pronounced that it can rarely if ever be completely reversed, is striking evidence that the varieties formed by progressive variation are distinct and discontinuous.

One of the interesting morphological possibilities is found in a problem under study, to determine whether new bud sports do not always appear first in the form of a variant leaf on the parent plant, this leaf showing the line of variation which the new form afterward fulfills. The solution of this problem depends on the possibility of determining whether each leaf has a subtending runner, and whether all the new plants from a given runner are alike and partake of the characteristics of the connected leaf. The problem, stated in other words, is to determine whether the actual process of variation takes place first in the cells of the leaf and is repeated in the runner and its sports, or whether the variation may not take place in the runner itself.

The fact that varieties in the division series do not always differ *inter se* merely by division, but also sometimes in the size and shape of the segments et al., and the further fact that other variations occur, such as dwarfing and ruffling, are in opposition to the conclusions reached by R. G. Leavitt,* who suggested that the appearance of varieties showing an increase in division was due merely to a translocation of the ability to divide from the whole leaf to the pinnae, a phenomenon to which he applied Bateson's term of homoeosis. To accept the hypothesis of such a translocation, it would be necessary to find that the twice-pinnate form differs from the once-pinnate form, from which it arose, merely in the amount of division, a supposition which is hardly supported by facts.

A further argument for the hypothesis of homoeosis adduced by Leavitt, and applied not only to these ferns but also, for example, to the horse-chestnut, lay in the fact that the new forms possessed no utilitarian advantage over their parents. The fact that the horse-chestnut leaf cuts off each pinna by a distinct callus as well as its petiole base, and that this double *decision* appears to have no adaptive value, was advanced as confirmatory of the homoeosis thesis. This is interesting, but will hardly be accepted as an argument in view of modern objections to teleological explanations. It may be noted that Eimer, twenty and more years ago, made a most determined stand against the belief that adaptability was a prime necessity in the appearance of new characters and the evolution of new forms.

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* Bot. Gaz. 47: 30–68. Ja 1909.

With respect to the present group of horticulturally produced forms, it appears evident that the lack of adaptability to natural conditions shown by most of them would prevent their establishment if they were to be introduced. This statement is probably true for the original sports of var. *bostoniensis* as well as for the forms of later vegetative generations, and this fact in itself is an adequate explanation of the non-occurrence of any of these forms wild. On this assumption they represent new forms produced in the course of evolution, most of which would be eliminated by the discriminating agency of natural selection. They differ therefore from wild forms showing the same types of variation, only in their non-adaptability. Certainly the three lines of variation along which these forms of *Nephrolepis* have been differentiated, and especially the lines of increase in division and dwarfing, can be paralleled by similar lines of variation among wild forms which have succeeded better because provided with the means to meet natural conditions of competition, etc. Certainly also the forms described in this paper comprise, within their extremes of variation, greater differences than are required for the differentiation for many natural species. For example, differentiation of species and even genera on the basis of leaf division is too common, not only among ferns but also among flowering plants, to require more than mention.

As possible corollaries to the statements of the preceding paragraphs, two points are of interest and may be indicated in the form of questions. Is the rapidity of evolution of these *Nephrolepis* varieties, fifty or more in fifteen years, any indication of the speed of evolution of wild forms of similar distinctiveness? Or does the fact, that nearly all if not all of these forms would lose out in the struggle for existence, indicate that, while the appearance of ill-adapted variations may be common, the appearance of successful variations is most uncommon?

In the preceding paragraphs it has been assumed that the variations of these cultivated ferns are homologous with similar variations occurring among wild species. If this is true, (that the two lines of variations are homologous) it is not improbable that the causes may be similar. These causes may be sought by experimental methods, by the cultivation of a variety which shows a relatively high coefficient of variability, as for example, *Teddy Jr.* They may be sought by cytological study of similar variations, as is shown by the production of dwarfs in many widely separated lines, or by the reversions. The cytological method would only show some possibly correlated facts of cell structure. The experimental method might show some connection between cultural methods and the appearance of new forms. In this connection it may be noted that Eimer and Coulter, perhaps the earliest and the latest to discuss the possible causes of orthogenetic variation, have both professed the opinion that climate is the probable causative agency.

The query has been expressed as to whether a hybrid origin might not account for these variations of *bostoniensis*. With this possibility in mind, one species of *Nephrolepis*, *N. biserrata*, which is co-extensive with *N. exaltata* in distribution, would seem to be worthy of investigation. It is hard to imagine, however, how the combination of any two twice-pinnate species of *Nephrolepis*, or indeed of any more dissimilar species, could account for the appearance not only of the three lines of variation but of the progressive intensification of these lines thereafter. The sterility of these forms is apparently the only feature these forms have in common with most hybrids, and this must presumably be accounted for in some other way.

For the present, all that can be said as to the genesis of these forms is they apparently proceed from some internal cause. It may be added that similar variations have occurred as a result of spore sporting, and also that similar variations are common wild. These forms may therefore be considered as indicating how species, showing similar differences, have arisen, that is, by what lines of variation. The evidence offered along this line by the progressive forms alone is most incomplete, however, without an understanding of the regressive variations as well.

D. SUMMARY OF FACTS AND CONCLUSIONS

1. *Nephrolepis*, a genus of once-pinnate tropical ferns, includes several species which are cultivated. Nearly all of these cultivated species show variation by bud sports, but *N. exaltata* through its variety *bostoniensis* is most prolific, having given rise

to more than one hundred different forms in less than fifteen years.

2. Cultural conditions are such as to favor the appearance and preservation of variations, because the soil and other environmental conditions are probably practically perfect, and because very large numbers of plants, one to two million, are grown per annum in the United States alone.

3. The variations may be classified under two headings, progressive, and regressive or reversive. Progressive varieties are defined as those which show less resemblance to var. *bostoniensis* than their parent forms. Regressive varieties are defined as those which show something of a return in characters toward var. *bostoniensis*.

4. Progressive variations have appeared along three main lines, viz., those showing increased division of the leaf; those showing increased ruffling of the pinnae; those showing dwarfing. Variations showing dichotomy of the pinnae and leaf tips also occur.

5. Progressive increase in division has gone through five vegetative generations, each succeeding step being an intensification of the preceding, the forms varying from once to five times pinnate. Progressive increase in ruffling has gone through three vegetative generations. Progressive dwarfing has gone through three vegetative generations.

6. The dwarfing seems to be clearly of two sorts: first, brachyotic or unilinear; and second, normal in all dimensions. More than one type of division sport is also indicated.

7. Progressive increase in leaf division and progressive dwarfing may be expected in any form which has not reached the limits of variation along these lines.

8. Regressive variations rarely if ever show complete return to their parent forms or to var. *bostoniensis*.

9. The indicated coefficient of variation for progressive variations is very low; probably between one in one million and one in one thousand. Regressive variation is much more common.

10. The variations are all discrete or discontinuous, not proceeding by imperceptible differences.

11. The progressive variations in their differences actually

parallel the differences existing between many wild species of ferns and flowering plants.

12. The main difference between these variations and those shown by wild forms lies in the fact that these horticultural forms do not possess adaptability to natural conditions. In most cases, with the variation, has come decreased vigor of growth.

13. The cause or causes of these variations are undetermined. They proceed as if from internal stimulation. The improved cultural conditions do not appear as causes, but rather as a means of preserving forms which, under wild conditions, would be eliminated by natural selection.

E. Index of the sports described above

Varieties showing increase in leaf division

Name	Producer
Anna Foster	Lucias Foster, Dorchester, Mass.
Barrowsi	Henry Barrows, Whitman, Mass.
Amerpohli	Edward Amerpohl, Janesville, Wis.
Elegantissima	F. R. Pierson, Tarrytown, N. Y.
Elegantissima-compacta	F. R. Pierson, Tarrytown, N. Y.
Elegantissima "improved"	F. R. Pierson, Tarrytown, N. Y.
Giatrasi	George Giatras, West Hoboken, N. J.
Goodi	Good & Reese, Springfield, Ohio.
Gracillima	Henry Barrows, Whitman, Mass.
Craigi	Robert Craig, Philadelphia, Penn.
Magnifica	Henry Barrows, Whitman, Mass.
Muscosa	F. R. Pierson, Tarrytown, N. Y.
Piersoni	F. R. Pierson, Tarrytown, N. Y.
Schilleri	J. L. Schiller, Toledo, Ohio.
Scholzeli	Herman Scholzel, New Durham, N. J.
Scholzeli, three-pinnate sport	Herman Scholzel, New Durham, N. J.
Smithi	John Clark, Washington Botanic Garden, Washington, D. C.
Whitmani	Henry Barrows, Whitman, Mass.
Whitmani compacta	Henry Barrows, Whitman, Mass.
Whitmani "improved"	Henry Barrows, Whitman, Mass.
Elegantissima sport, like Whitmani compacta	George Giatras, West Hoboken, N. J.

Varieties showing progressive ruffling

Name	Producer
Var. bostoniensis	?F. C. Becker, Cambridge, Mass.
Harrisi	Wm. K. Harris, Philadelphia, Pa.
Wm. K. Harris	Wm. K. Harris, Philadelphia, Pa.

Roosevelti	American Rose & Plant Co., Springfield, Ohio.
Roosevelti sport, like Wm. K. Harris.	American Rose & Plant Co., Springfield, Ohio.

VARIETIES SHOWING PROGRESSIVE DWARFING

Name	Producer
Elegantissima-compacta	F. R. Pierson, Tarrytown, N. Y.
Elmsfordi	Scott Bros., Elmsford, N. Y.
Giatrasi	George Giatras, West Hoboken, N. J.
Giatrasi, dwarf sport of	George Giatras, West Hoboken, N. J.
Schultheisi	Anton Schultheis, College Point, N. Y.
Scotti	John Scott, Brooklyn, N. Y.
Superbissima	F. R. Pierson, Tarrytown, N. Y.
Wagneri	Peter Wagner, Brooklyn, N. Y.

VARIETIES SHOWING DICHOTOMY OF PINNAE

Name	Producer
Falcata	Peter Wagner, Brooklyn, N. Y.
Splendida	Good & Reese, Springfield, Ohio.

VARIETY OF UNCERTAIN CHARACTER

Name	Producer
Wittboldi	Wittbold, Chicago, Ill.

Explanation of plates 10–15

All photographs made to about the same scale except on Plates 11 and 14.

PLATE 10

Leaves illustrating a division series. FIG. 1. Var. *bostoniensis*. FIG. 2. *Piersoni*. FIG. 3. *Whitmani*. FIG. 4. *Magnifica*. FIG. 5. *Craigi*.

PLATE 11

Pinnae illustrating a division series. FIG. 1. Var. *bostoniensis*. FIG. 2. *Piersoni*. FIG. 3. *Whitmani*. FIG. 4. *Goodi* (or *gracillima*). FIG. 5. *Magnifica*. FIG. 6. *Craigi*. FIG. 7. *Amerpohli*.

PLATE 12

Illustrating one secondary and four direct sports of *Piersoni*. FIG. 1. *Elegantissima*. FIG. 2. *Elegantissima-compacta*. FIG. 3. *Splendida*. FIG. 4. *Superbissima* (small leaf). FIG. 5. *Goodi* (or *gracillima*). FIG. 6. *Muscosa*. FIG. 7. *Elmsfordi*.

PLATE 13

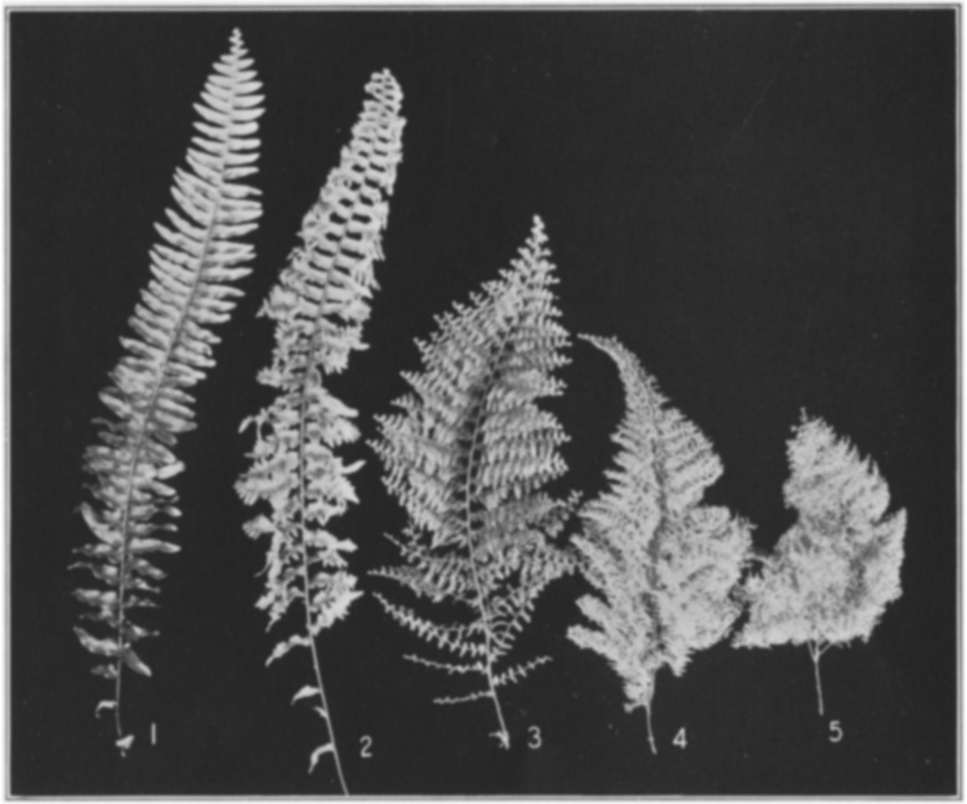
Illustrating variations in ruffling and dwarfing. FIG. 1. *Nephrolepis exaltata*. FIG. 2. Var. *bostoniensis*. FIG. 3. *Harrisi* (or *Roosevelti*). FIG. 4. *Wm. K, Harris* (or new sport of *Roosevelti*). FIG. 5. *Teddy Jr*. FIGS. 6–8. Dwarf sports of *Teddy Jr*. FIG. 7. *Randolphi*.

PLATE 14

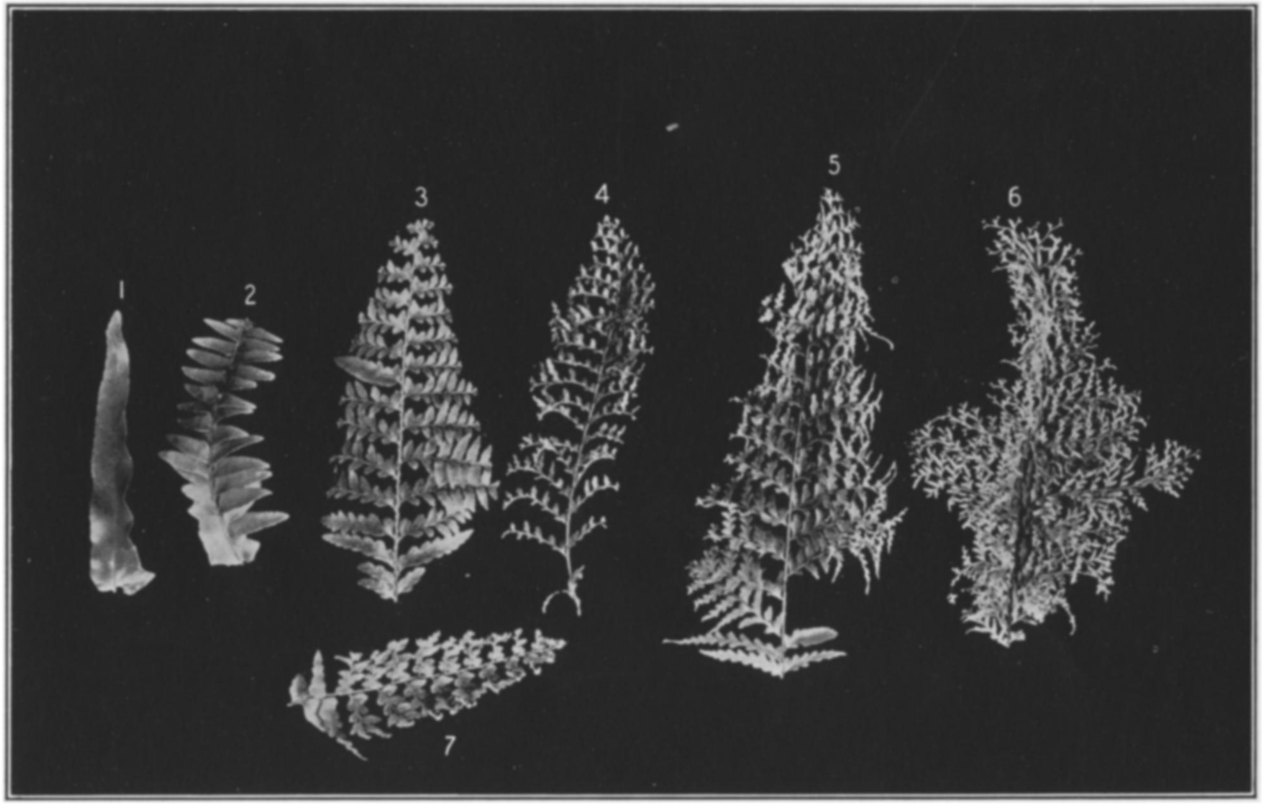
Pinnae illustrating dwarfing and sports of *Scotti*. FIG. 1. Var. *bostoniensis*. FIG. 2. *Scotti*. FIG. 3. *Wagneri*. FIG. 4. *Falcata*. FIG. 5. *Scotti*. FIG. 6. *Wagneri*. FIG. 7. *Scholzeli*. FIG. 8. Three-pinnate sport of *Scholzeli*.

PLATE 15

Illustrating dwarfing and sports of *Giatrasi*. FIG. 1. Var. *bostoniensis*. FIG. 2. *Giatrasi*. FIG. 3. Dwarf sport of *Giatrasi*. FIG. 4. Two-pinnate sport of *Giatrasi*.



BENEDICT: VARIETIES OF NEPHROLEPIS



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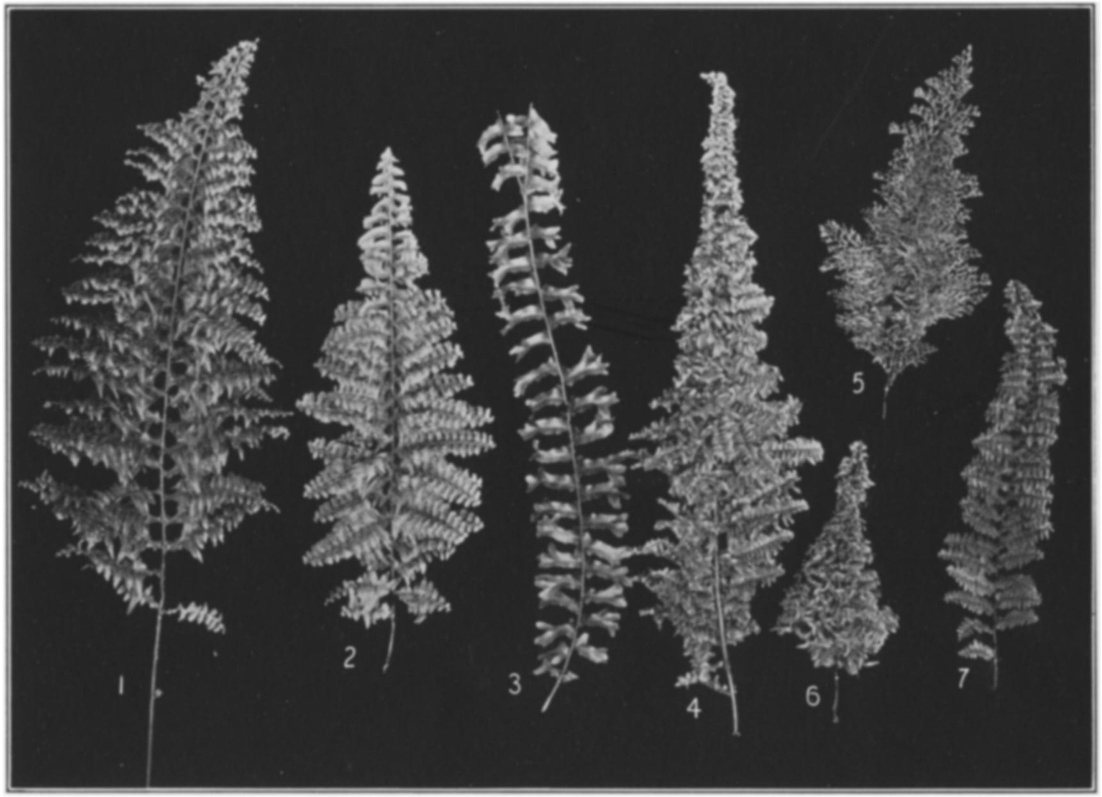

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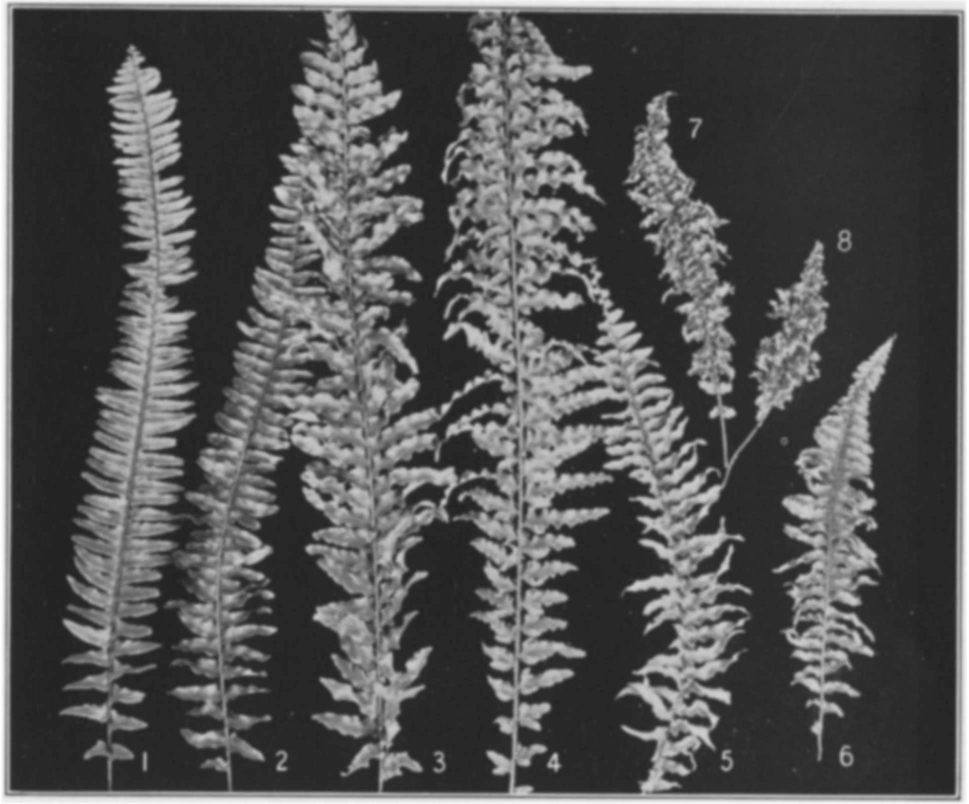

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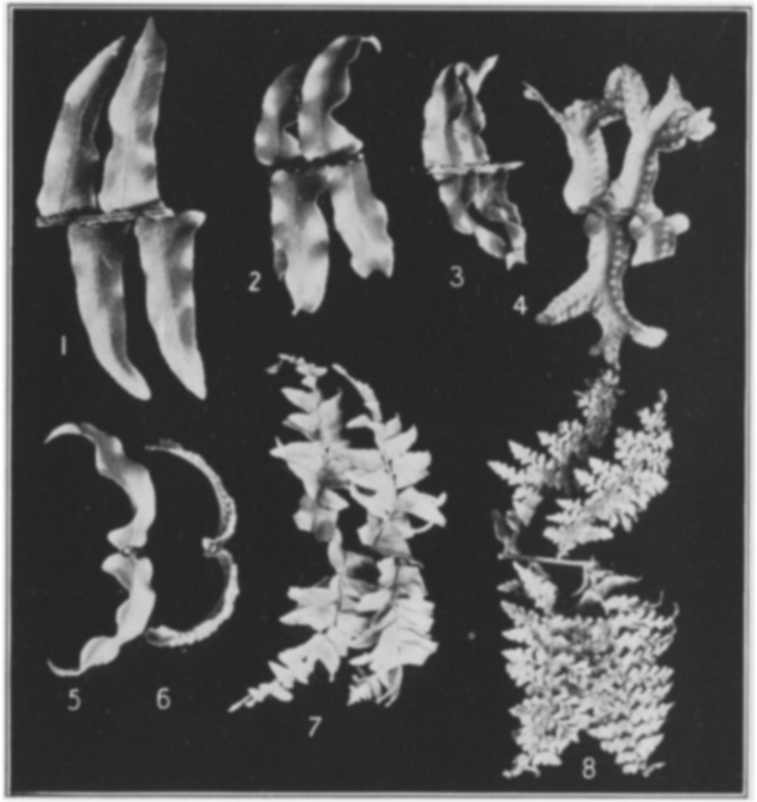

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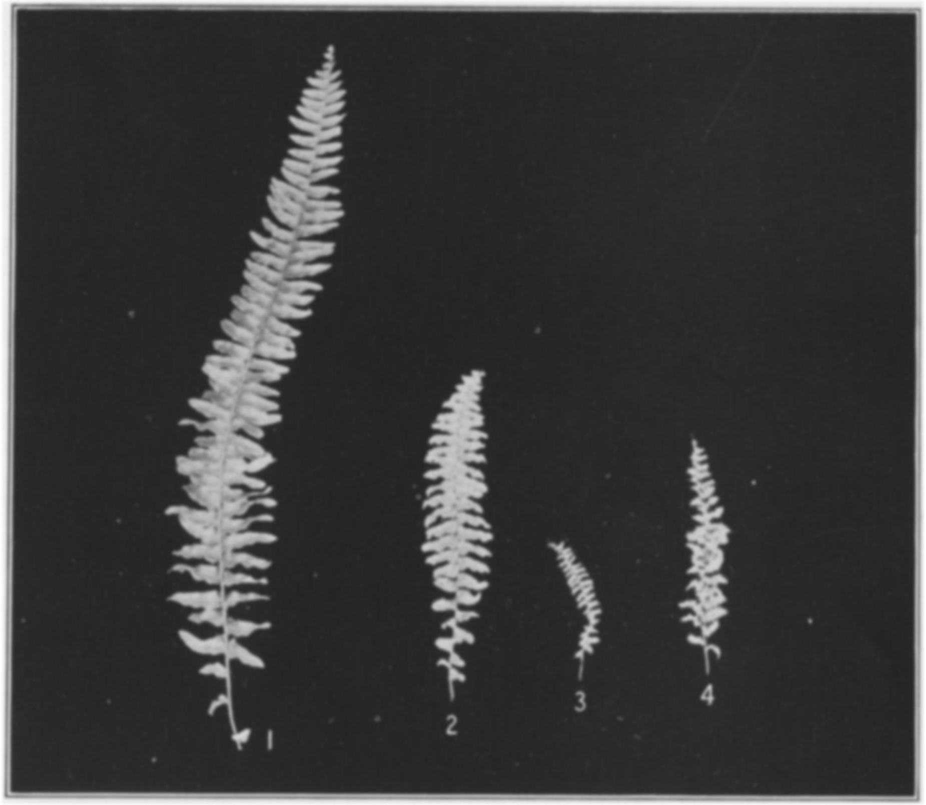

BENEDICT: VARIETIES OF NEPHROLEPIS